



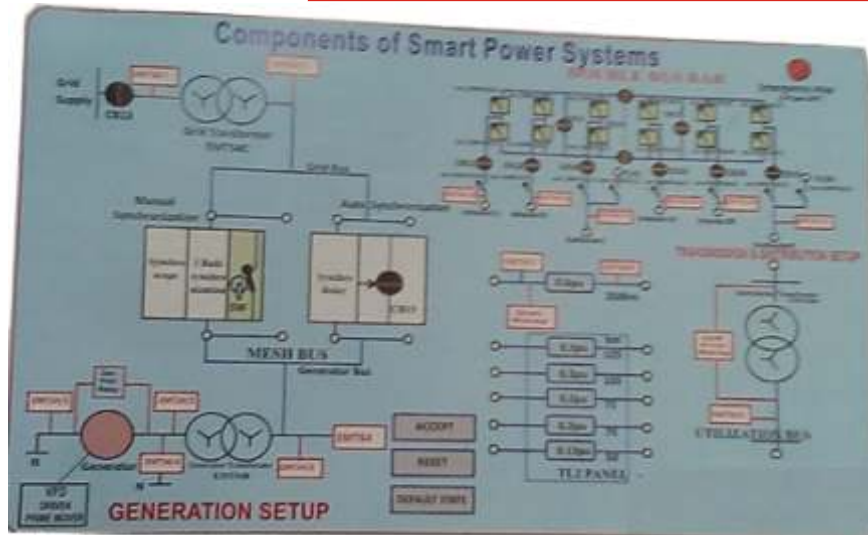
### **SALIENT FEATURES**

1. The objective of this trainer is to develop a real time automated power system network and control test-bed at the laboratory level to enhance student understanding about the power system testing and validation
2. Trainer offers laboratory experiments and their analysis giving students a high level of knowledge to understand the concepts of power system engineering fundamentals and the required demonstrations needed for smart grid implementation in the real world.
3. SPS system consists of 4 nos. of power engineering setups viz; Generation, Synchronization, Double Bus Bar, Transmission & Distribution, 4Nos. of integrated Numeric protection relays like Generation protection, Transformer protection, 3 nos. of RTU with ethernet & RS485/MODBUS ports, 3 nos. of touch panel local station HMI's 1 No. of supervisory controller / touch cords/cables to integrate seamlessly various parts into single system, 8 nos of aluminum profile tables with under trolleys / drawers etc.
4. Table top resources needed by respective setups are placed on Trolley below the table having wiring access through slot provided in the center of setup tables.
4. Table top resources needed by respective setups are placed on Trolley below the table having wiring access through slot provided in the centre of setup tables.
5. The individual modular flat demo panel setups can also be worked jointly (automated SCADA) or severally (manual expts) thereby accommodating more student capacity whenever time demands.
6. Facilitates easy and safe wiring by students due to use of 4mm sturdy Shrouded banana patch cords for high voltage circuits.
7. **Options:** **A)** 2nd generation Station may be added using three phase alternator using two more setups, of generation & synchronization respectively, with included to HMI & RTU. **B)** A DFIG setup may be included to simulate wind power generation. The generation setup here will include AC to ACIGBT based VFD to illustrate wind power grid tied generator. **C)** A lab saced solar power based grid tied setup may be included.
8. Useful for Post Graduate projects and research purpose.
9. Student friendly Instructor Guide & Student Workbooks giving detail experiment procedures, wiring schedule & tabular results.

Note: Specifications are subject to change.

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## Technical Specifications

### 1) SCADA components

**A) PCs:** 4th generation Intel Core ,2.9GHz,2-Core,OS: Windows 8.1, Memory: 8GB, HDD: 500GB, Smart space-saving All-in-One design with a full-metal V-stand-4Nos.

- i) Supervisor's desk: Touch panel PC with 8 port Ethernet switch-1nos
- ii) HMIs as local stations: Touch panel PC placed near each Rtu unit with convenient swivel angle-3nos
- iii) Uninterruptible Power Supply: Provided (500VA/30 min. backup) one each for supervisory PC & 3 HMI station to prevent corruption due to brownouts.-4nos.

### B) Software:

- i) Multi drop SCADA software with 4 numbers of USB based runtime hard keys, of which 2 are for unlimited tags & two are of 300 tags.
- ii) SCADA screens supported: Generator control panel screen, synchronization screen Generator different protection relay screen, load screen selection screen, Double bus bar screen, transmission line screen, symmetrical & unsymmetrical fault screen, Distance protection screen, Distribution Transmission different protection screen, power measurement screen, Alarm and event management screen etc.

### C) RTUs: Table top aluminum profile rack of 3X1 panels consisting

- 3nos.

- i) Each PLC (48I/O) has 24 inputs (24V) & 24 output (Relay additionally 2al & 3AO. Each PLC has RS485 modbus interface, Ethernet interface, 8 relay output card (max 3nos) with contacts at 230vac with terminal strip for easy servicing.
- ii) Converter cum distribution panel (CDP) supporting 37 pin & 9 pin D connectors for control & collecting trip signal from protection relays if any.



RTU Unit with HMI

- iii) 3 phase 4P/16A@415vac contactors for power topology control, fault insertions & CB control-20nos (max).
- iv) Goggle coloured transparent Perspex glass cover to protect students from HV compnents / contactors.

### D) IEDs:

- i) Multifunction meter EMT34: Consist of (96 X 96 mm) Digital meters for 3 phase, VARs, energy etc. with RS485 modbus communication interface facility-15nos.
- ii) Phase angle measurements-2nos
- iii) Protection Relays: Numeric relays with modbus RS485 interface.-4nos
  - a) Generator protection differential relay provides differential, over/under voltage frequency, reverse power, earth fault, directional/non directional etc.
  - b) Distance protection relay provides distance zone, directional/non directional over current, earth fault, Under/Over voltage protections, auto reclose function etc.
  - c) Transformer differential protection relay provides differential protection & over current protection for distribution transformer.
  - d) Automatic synchronization relay provide automatic synchronization between generator & Grid supply.

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### E) VFD:

Variable voltage variable frequency drive (7 KW) to control prime mover, having modbus communication over RS485 interface facility and with analog input 0-10V for frequency synchronization & 0-2.5V to control excitation of alternator EMT-9 (0-100DC O/P).

### 2) Power engineering stations/ Setups (supplied mounted on aluminum profile slotted table, with under trolley.



Individual setup

- a) **Generation trainer** - Refer XPO-SPS/Gen catalogue for generation trainer.
- b) **synchronization Trainer** - Refer XPO-SPS/Sync catalogue for synchronization Trainer.
- c) **Transmission & Distribution trainer** - Refer XPO-SPS/TLD catalogue for Transmission & Distribution Trainer.
- d) **Double bus Bar** - Refer XPO-SPS/DBB catalogue for substation double bus bar trainer.

### 3) Transformers:

- a) **Generator group** - 3 phase power transformer 3KVA/5KVA, YY11 connection, with multi-tapped secondary windings
- b) **Grid transformer** - 3 phase power transformer with connection group YY11, 5KVA, with multi-tapped secondary windings.
- c) **Distribution transformer** - 3 phase power transformer, 3KVA, phasor group YY11, With multi-tapped secondary.



Transformer



Under Trolley resources

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### 4) Accessories:

#### a) Tables for RTU: 4 nos, consists of pi type holding frame, table top drawers etc.

- i) **Frame:** 45X45 aluminum profile square block (Heavy duty) Colour : anodized white.
- ii) **Table top material/colour:** The nova pan or Rubber wood with white/Silver gray with smooth finish veneer finish table top (25 mm thickness)
- iii) **Drawers:** Out of 3 drawers one is open type & would double up as PC keyboard carrier with mouse pad on its side. Other two drawers are closed type, lockable of these two, bottom drawer has double height to accommodate tall components. Pull out writing pad provided above upper drawer.
- iv) **Mechanical:** Four sturdy castor wheels with locking mechanism are provided so that table can be easily moved, **Dimension:** 1200 mm (L) X 750 mm (W) X 760 mm (H)

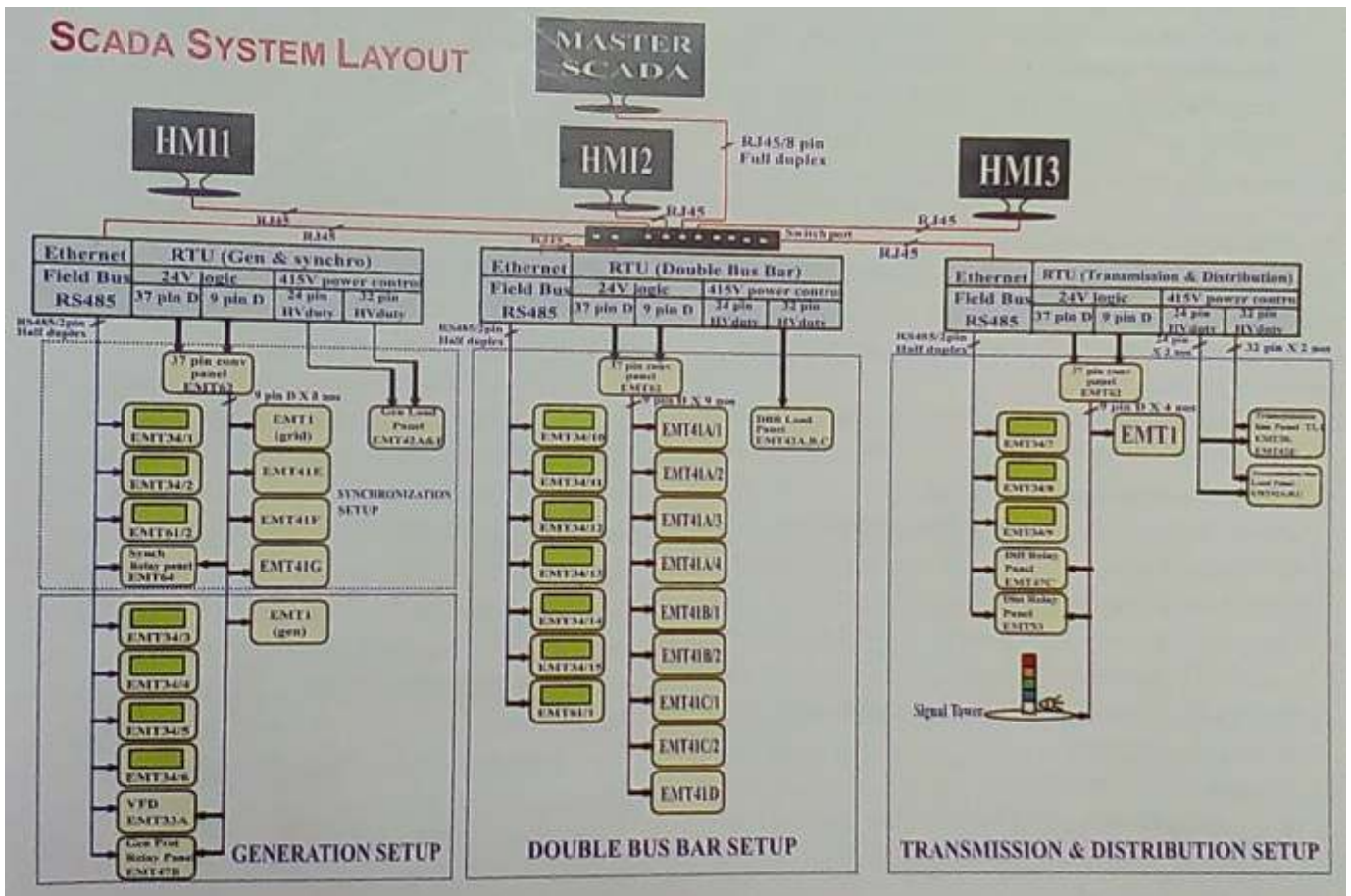
#### b) Cables:

- i) 9 pin D male to 9 pin D female with 9 core cable, length up to 6 meter - 21nos.
- ii) 37 pin D male to 9 pin D female patch cable, length up to 4 meters - 3nos.
- iii) 3 phase power extension: 5pin 3 phase plug male to 5 pin 3 phase plug male cable, 1.5meter - 3nos.
- iv) RS485 patch cable: 6 pin mini DIN male to 6 pin mini DIN male length up to 1200mm - 22nos.

### List of experiment

- i) Automatic as well as manual Synchronization of generator with grid supply.
- ii) Study of V curve & inverted V curve.
- iii) Study of Generator performance chart.
- iv) Study of generator protection for differential, over current, over/under voltage, over/under frequency, reverse power and earth faults using generator protection relay.
- v) Study of voltage variation & control.
- vi) Study of voltage regulation for constant cos  $\phi$ .
- vii) 3 bus load flow study.
- viii) Study of No load test ferranti effects on transmission line.
- ix) Load test and calculation of efficiency, regulation and power flow in pi model of TL.
- x) Load test and calculation of efficiency, regulation and power flow in short model of TL.
- xi) Study of symmetrical and asymmetrical faults on transmission line.
- xii) Study of distance protection using distance relay.
- xiii) Study of Auto reclose function of distance relay.





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### SALIENT FEATURES

VFD drive is used to control brushless prime mover's speed in manual using RTU/SCADA as well as in auto mode using synchronization relay. Multi function meters read the input voltage & frequency of generator output along with power analyser data on MODBUS.

The Generator/ alternator coupled with prime mover have brought out six terminals from three phase 3 windings (RYBs). The every alternate terminal of RYB is shorted and connected together to form star connection (Neutral at the output of generator)

The relay panel carries shrouded sockets to connect **Generator protection relay** mounted

below. The CT panel and PT panel provide necessary interface between real world & relay. Emergency stop mushroom switch is provided with security key lock on the profile rack.

Facilitates easy and safe wiring by students due to use of 4mm sturdy shrouded banana patch cords and shrouded socket arrangements for high voltage circuits.

Each panel has ABS molded plastic sturdy enclosure, and colorful screwless overlays showing circuits diagrams & its connection tag numbers for easy understanding and connection. Useful for Post Graduate projects and research purpose.

Set to Instructor Guide & Student Workbook.

### Technical Specifications

**This trainer can work in standalone mode with simulated grid sources as well as in conjunction with synchronization setup, HMI, RTU SCADA software and consists of following panels:**

#### Input 3 phase DOL Starter panel (TMT1) X 1Nos

- 3 pole MCB of 415 v/20A.
- Dol 16A Contactor with 24SCV / 11VA COIL
- Bimetallic thermal O/L relay with range 9A - 15A
- RYB inputs indicators
- 9 pin D (M) connector for SCADA interface
- Manual start / stop with local trip contact
- power ON LED indicator

#### DC Voltmeter & DC ammeter Panel (TMT6B) X 1Nos

- DC voltmeter 0-300VDC
- DC ammeter 0-5A
- 4A circuit breaker

#### Instrumentation power supply cum multichannel DPM panel (TMT8) X 1No.

- Power supply +12V, - 12V, 500 mA, +5V/300mA
- Unregulated 17VDC / 750 mA
- Line synchronizing signal
- Multi channel DPM for digital display of torque &

speed

#### Variable AC and DC supply panel (TMT 23) X 1No.

- Input 0-230VAC, 50Hz
- Variable O/P: AC 0-270V/3A
- Variable O/P: DC 0-250v/3A

#### IGBT Controlled VVVF Drive panel (TMT 33A) X 1 No.

- Input voltage: 3 phase, 415VAC. 50Hz
- Output voltage: 3 phase 415VAC
- Range (Frequency Control) : 0.1Hz to 100(400)Hz
- Control Mode : Sine Wave PWM
- Capacity : 10 HP
- With Reverse And Forward Direction
- 3 phase EMI Inductor
- Mod bus RS485 interface
- 9 pin D (M) connector for RTU/SCADA interface

#### 3 phase Bidirectional Power cum Energy meter panel (TMT 34) X 4 Nos.

- Bidirectional Multifunction
- 3 phase 3/4 wire, 415VAC, CT Input 5A
- LCD / LED display, Aux, supply 230V, 45-64Hz,5W
- Measure V.I., Hz, Pf, KVA, KW, KWH

Note: Specifications are subject to change.

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- Supports signal conditioning circuit for speed, torque in kg to give output 0-2.5Vdc (FS)
- External control signal (0 - 2.5VDC) to set O/P volt (0-100VDC) to control excitation

#### Generator protection Relay panel (TMT 47B) X 1 No.

- Protections: Differential, Over current, Under/Over voltage, Under/Over frequency, Reverse power, Earth fault.
- 9 pin D (M) connector to interface with RTU/SCADA for automation
- Modbus RTU RS 485 for RTU/SCADA interface

#### CT panel (TMT 47B) X 1 No.

- Consist of 5/5 Amp. CT6 Nos
- Primary side of CTs are brought on 3 X 2 X 2 SBS-5 sockets
- Secondary side fo CTs are star connected in group of 3 & brought out on 4 X 2 SBS-5 sockets

#### 415/110VAC, 50VA PT panel (TMT 54) X 1 No.

- Consisting of potential transformer,
- Input 415VAC, star connected, Output 110VAC, star connected, 50VA

#### 5 pin to shrouded socket converter panel (TMT 54) X 1 No.

- Consist of 5 pin 3 phase, 5wires industrial female socket to connect 415VAC 3 phase supply
- shrouded banana sockets 18 nos to extend the 3 phase supply into individual setups
- It's used as bidirectional 3 phase extension board between two setups

#### Table top panels:

##### Generator transformer panel (TMT 54B) X 1 No.

- 3 phase power transformer with connection group YY11,
- Input 415VAC, Output 415VAC, 5KVA,
- Secondary winding with tapping at  $\pm 2.5\%$  and  $\pm 5\%$

##### 3 phase Squirrel cage Induction Motor panel (TMT 65) X 1 No.

- Voltage: 3 phase Delta connected, 415 VAC, 50Hz,
- Capacity/RPM / Terminals: 10HP/4 pole m/c / 1500RPM/6 terminals
- Rotor Construction: Diecast Squirrel cage rotor
- Stator construction: 3X2 terminals
- Frame / Mounting shaff dia: 132 frame, chasis mounted 38mm dia. with easily swappable gear coupling

#### 3 phase Salient Pole Alternator panel (TMT 65) X 1 No.

- Voltage : phase, star connected, 415VAC, 50Hz
- Capacity / RPM / Terminals: 3KVA/4 Pole m/c 1500RPM
- Rotor Construction: Rotor excited 180Vdc/2.65A two terminals brought out on 2 slip rings mounted on shaft
- Stator construction: Six terminals brought out for star connection
- Frame / Mounting Shaft dia: 132 Frame, Chasis mounted 28mm dia. With easily swappable gear coupling

#### Mechanical Dimension (mm) / Wt. (kg):

- Rack: 1170(L) X 300(W) X 990(H) / Net Wt.: 65, Gross Wt.: 73
- Coupled machine: 1250 (L) X 450(W) X 500(H) / Net. Wt: 80
- Gen X'mer: 770 (L) X 275(W) X 435(H) / Net Wt.: 53

#### Accessories:

##### a) Table for Generation Setup: 1 no. consist of Pi type frame

- Frame: 45X45 aluminum profile (Heavy duty) Colour: anodized white.
- Table top material/colour: The nova pan or Rubber wood with white/Silver gray with smooth finish veneer finish table top (25mm thickness) with removable slot cover (900X500mm)
- Provision to insert MS Sturdy mesh cover on front side to protect student from rotating machines below
- Dimension: Table: 1450mm (L) X 750mm(W) X 760mm(H)
- Caster wheels: Four sturdy castor wheels with locking mechanism are provided so that table can be positioned conveniently

##### a) Cables:

- 9 pin D male to 9 pin D female with 9 core cable, length up to 6 meter - 3 nos
- 37 pin D male to 37 pin D female patch cable, length = 4 meters
- RS 485 patch cable: 6 pin mini DIN male to 6 pin mini DIN male, length up to 1100mm - 3 nos

#### List of Experiments:

- Automatic as well as manual Synchronization of generator with grid supply
- Study of V curve & inverted V curve
- Study of Generator performance chart
- Study of generator protection for differential, over current, over/under voltage, over/under frequency, reverse power and earth faults using

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### SALIENT FEATURES

To synchronize the Generator with grid, this synchronization setup is used.

Automatic operation can be performed in two ways namely; from screen based generator control panel using increment and decrement screen buttons or using synchronization relay whose 4 contacts (incr/decr) are read by RTU through 9 pin D (M) connector on synchronising relay panel & outputs two AO's through 9pin D connector on vfd panel one for excitation (V) control & second for speed (f) control.

Emergency stop mushroom switch is provided with security

key lock on the vertical profile member.

Facilitates easy and safe wiring by students due to use of 4mm sturdy Shrouded banana patch cords and shrouded socket arrangements for high voltage circuits.

Each panel has ABS molded plastic sturdy enclosure, an colorful screwless overlays showing circuits diagrams & its connection tag numbers for easy understanding and connection.

Useful for Post Graduate projects and research purpose. Set fo Instructor Guide & Student Workbook.

### Technical Specifications

This trainer work only in conjunction with Generator setup, HMI, SCADA software and consists of following panels:

#### Input 3 phase DOL Starter panel (TMT1) X 1Nos

- 4 pole MCB of 415 v/20A.
- Dol 16A Contactor with 24DCV / 11VACOIL
- Bimetallic thermal O/L relay with range 9A - 15A
- RYB inputs indicators
- 9 pin D (M) connector for SCADA interface
- Manual start / stop with local trip contact
- power ON LED indicator

#### DC Voltmeter & DC ammeter Panel (TMT6B) X 1Nos

- DC voltmeter 0-300VDC
- DC ammeter 0-5A
- 4A circuit breaker

#### Synchronization anel (TMT8) X 1No.

- Consisting of synchronization digital meter (Synchroscop),
- Manual Synchronization switch
- 15W lamp X 6 nosl
- Manual start / stop with local trip conact

#### 3 phase Bidirectional Power cum Energy meter panel (TMT 34) X 2 Nos.

- Bidirectional Multifunction
- 3 phase 3/4 wire, 415VAC, CT Input 5A
- LCD / LED display, Aux, supply 230V, 45-65Hz,5W

- Measure V.I., Hz, Pf, KVA, KW, KWH
- Modbus RTU RS 485 for SCADA

#### Mesh bus Generator panel (TMT 41E) X 1No.

- Consisting of 2-isolator switches,
- Circuit breaker, Generator bus, Grid bus, generator in feeder.
- 9 pin D (M) connector to interface with scada for automation
- Manual start/stop with local trip- contact
- Power ON LED indicator

#### Mesh bus Frid panel (TMT 41F) X 1No.

- Consisting of 2-isolator switches,
- Circuit breaker, Generator bus, Grid bus, generator in feeder.
- 9 pin D (M) connector to interface with scada for automation
- Manual start/stop with local trip- contact
- Power ON LED indicator

#### Synchronization bus switch panel (TMT 41G) X 1 No.

- Consisting of circuit breaker, Main bus, Reserve bus
- 9 pin D (M) connector to interface with scada for automation
- Power ON LED indicator

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**415/110VAC, 50VA PT panel (TMT 54) X 1 No.**

- Consisting of potential transformer
- Input 415VAC, star connected, Output 110VAC, star connected, 50VA

**Phase Angle meter panel (TMT 61) X 1 No.**

- Measure phase angle between two voltages
- Internally 2 PTs for isolation
- Modbus RTU RS 485 interface for SCADA

**415/110VAC, 50VA PT panel (TMT 54) X 1 No.**

- Consisting of potential transformer,
- Input 415VAC, star connected, Output 110VAC, star connected, 50VA

**37 pin D (M) to 9 pin (F) converter panel (TMT 54) X 1 No.**

- Consist of 37 pin D type male 1no., 9pin D type male 1 no.
- 9 pin D type female connectors 9 nos
- Power ON LED

**5 pin to shrouded socket converter panel (TMT 63) X 2 No.**

- Consist of 5 pin 3 phase, 5 wires industrial female socket to connect 415VAC 3 phase supply
- shrouded banana sockets 18 nos to extend the 3 phase supply into individual setups
- It's used as bidirectional 3 phase extension board between two setups

**Synchronization relay panel (TMT 41G) X 1 No.**

- Consisting of automatic synchronization relay, Generator bus, Grid bus
- 9 pin D (M) connector to interface with RTU/scada for automation
- Power ON LED indicator

**Table top panels:**

**Transmission line panel TL2 (TMT 38A/B/C) X 1 No.**

- Consisting of 5 numbers of transmission lines
- 2 Transmission lines of 0.3pu for 125Km.
- 2 Transmission lines of 0.2pu for 75Km.
- 1 Transmission lines of 0.13pu for 50Km.

**R lode panel (TMT 42A & 42E) X 1 No.**

- 3 nos of 600W resistors with switch selectable 6 nos of taps at 100, 112, 150, 175, 200 & 225 ohm
- Fault resistor 100ohm/600W

1500RPM/6 terminals

- Multi pin heavy duty connector 32 pin & 24 pin to establish control from RTU/SCADA

**Grid transformer panel (TMT 54C) X 1No.**

- 3 phase power transformer with connection group YY11,
- Input 415VAC, Output 415VAC,5KVA,
- Secondary winding with tapping at 2.5% and 5%

**Mechanical Dimension (mm) / Wt. (kg):**

- Rack: 1170(L) X 300(W) X 990(H) / Net Wt.: 65, Gross Wt.: 73
- TL2: 600 (L) X 385(W) X 500(H) / Net. Wt: 103
- Lode & fault panel: 600 (L) X 275(W) X 500(H) / Net. Wt: 60
- Grid X'mer: 770 (L) X 275(W) X 435(H) / Net Wt.: 53

**Accessories:**

**a) Table for Synchronization Setup: 1 no. consist of Pi type frame**

- Frame: 45X45 aluminum profile (Heavy duty) Colour: anodized white.
- Table top material/colour: The nova pan or Rubber wood with white/Silver gray with smooth finish veneer finish table top (25mm thickness) with removable slot cover (900X500mm)
- Under trolley: Located under individual setup table to house respective load panel, transmission line panel variac panel, transformer etc as applicable
- Dimension: Table: 1450mm (L) X 750mm(W) X 760mm(H) under trolley: 1200X700X185
- Caster wheels: Four sturdy castor wheels with locking mechanism are provided so that table can be positioned conveniently

**a) Cables:**

- 9 pin D male to 9 pin D female with 9 core cable, length = 0.450 to 6 meter - 3 nos
- 37 pin D male to 37 pin D female patch cable, length = 4 meters
- RS 485 patch cable: 6 pin mini DIN male to 6 pin mini DIN male, length 0.480 to 1.180 meter - 3 nos

**List of Experiments:**

- Automatic as well as manual Synchronization of generator with grid supply
- Study of V curve & inverted V curve
- Study of Generator performance chart

Note: Specifications are subject to change.

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### SALIENT FEATURES

The Model represents a double bus bar switching station with 9 switching bays. It is equipped in such a way that the requirements of the both the grid and the power station operation are dealt in practice oriented way. Two bus bar segments are represented. Here the interlocking conditions in a switching station can be learned in order to conduct safe switching operations, as the situation requires, on the grid and power plant.

The Double bus setup is used for bus and four bus load flow study.

Can use different KVA rating grid transformer in absence of actual generation setup to

simulate source of power wiring by students due to use of 4mm sturdy Shrouded banana patch cords and shrouded socket arrangements for high voltage circuits.

Facilitates easy and safe wiring by students due to use of 4mm sturdy Shrouded banana patch cords and shrouded socket arrangements for high voltage circuits.

Each panel has ABS molded plastic sturdy enclosure, and colorful screwless overlays showing circuits diagrams & its connection tag numbers for easy understanding and connection.

Useful for Post Graduate projects and research purpose.

Set fo Instructor Guide & Student Workbook.

### Technical Specifications

This trainer can work only in standalone mode with simulated grid sources as well as in conjunction with Generation setup, Synchronization setup HMI, RTU SCADA software and consists of following panels:

#### In feeder panel (TMT41A) X 4 Nos

- Consisting of 3-isolator switches
- Circuit breaker, Main bus, Reserve bus, Feeder
- 9 pin D connector to interface with SCADA automation
- Manual start/stop with local trip contact

#### Bus coupler panel (TMT 41B) X 2 Nos

- Consisting of circuit breaker, Main bus, Reserve bus
- 9 pin D connector to interface with SCADA automation
- Manual start/stop with local trip contact

#### Out feeder panel (TMT 41C) X 2 No.

- Consisting of 4-isolator switches
- Circuit breaker, Main bus, Reserve bus, Transfer bus/Earth switch, Feeder
- 9 pin D connector to interface with SCADA automation
- Manual start/stop with local trip contact

#### Section coupler panel (TMT 41D) X 1 Nos

- Consisting of 2 circuit breaker, Main bus, Reserve bus
- 9 pin D connector to interface with SCADA automation

- Manual start/stop with local trip contact

#### 3 phase Bidirectional Power cum Energy meter panel (TMT 34) X 6 Nos.

- Bidirectional Multifunction
- 3 phase 3/4 wire, 415VAC, CT Input 5A
- LCD / LED display, Aux, supply 230V, 45-65Hz,5W
- Measure V.I., Hz, Pf, KVA, KW, KWH
- Modbus RTU RS 485 for SCADA

#### Phase Angle meter panel (TMT 61) X 1 No.

- Measure phase angle between two voltages
- Internally 2 PTs for isolation
- Modbus RTU RS 485 interface for SCADA

#### 37 pin D (M) to 9 pin (F) converter panel (TMT 62) X 1 No.

- Consist of 37 pin D type male 1no., 9pin D type male 1 no.
- 9 pin D type female connectors 9 nos
- Power ON LED

#### 5 pin to shrouded socket converter panel (TMT 63) X 3 No.

- Consist of 5 pin 3 phase, 5 wires industrial female socket to connect 415VAC 3 phase supply
- shrouded banana sockets 18 nos to extend the 3 phase supply into individual setups
- It's used as bidirectional 3 phase extension board between two setups

Note: Specifications are subject to change.

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**Table top panels:**

**3 phase Dimmer panel (TMT 20D) X 1 No.**

- Consisting of 5 numbers of 1 phase dimmers connected in star
- Input 415VAC, 60Hz, Output 0-470VAC, 6A, 3 phase

**Transmission line panel TL2 (TMT 38A/B/C) X 1 No.**

- Consisting of 5 numbers of transmission lines
- 2 Transmission lines of 0.3pu for 125Km.
- 2 Transmission lines of 0.2pu for 75Km.
- 1 Transmission lines of 0.13pu for 50Km.

**RLC lode panel (TMT 42A & B/C) X 1 No.**

- 3 nos of 600W resistors with switch selectable 6 nos of taps at 100, 112, 150, 175, 200 & 225 ohm
- 3 nos of inductor 1.5H/1A with switch selectable 6 nos of taps at 0.3, 0.6, 0.75, 0.9, 1.2 & 1.5H
- Capacitors 440VAC rating (3 nos, one per phase) with switch selectable 7 nos of value of 2, 5, 10, 15, 20, 30 & 50 $\mu$ F
- Multi pin heavy duty connector 32 pin & 24 pin to establish control from RTU/SCADA

**Accessories:**

**a) Table for DBB Setup: 1 no. consist of Pi type frame**

- Frame: 45X45 aluminum profile (Heavy duty) Colour: anodized white.
- Table top material/colour: The nova pan or Rubber wood with white/Silver gray with smooth finish veneer finish table top (25mm thickness) with removable slot cover (900X500mm)

iii) Under trolley: Located under individual setup table to house respective load panel, transmission line panel variac panel, transformer etc as applicable

iv) Dimension: Table: 1450mm (L) X 750mm(W) X 760mm(H) under trolley: 1200X700X185

v) Caster wheels: Four sturdy castor wheels with locking mechanism are provided so that table can be positioned conveniently

**a) Cables:**

i) 9 pin D male to 9 pin D female with 9 core cable, length up to 6 meter - 3 nos

ii) 37 pin D male to 37 pin D female patch cable, length 4 meters - 1 nos

iii) RS 485 patch cable: 6 pin mini DIN male to 6 pin mini DIN male, length up to 1230mm - 6 nos

iv) 3 phase power extension: 5 pin 3 phase plug male to 5 pin 3 phase plug male cable, 1.5 meter - 1 nos

**Mechanical Dimension (mm) / Wt. (kg):**

• Rack: 1170(L) X 300(W) X 990(H) / Net Wt.: 65, Gross Wt.: 73

• Variac panel: 600 (L) X 275(W) X 500(H) / Net. Wt: 53

• TL2: 600 (L) X 385(W) X 500(H) / Net. Wt: 103

• RLC load panel: 600 (L) X 275(W) X 500(H) / Net Wt.: 60

**List of Experiments:**

i) Study of Voltage variation & control

ii) Study of voltage regulation for constant cos

iii) 3 bus load flow study

iv) 4 bus load flow study

Note: Specifications are subject to change.

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### SALIENT FEATURES

The setup is used for transmission line study for short as well as long line Pi model, ferranti effects regulation / efficacy calculations, symmetric / asymmetric fault study. This setup also covers protection of transmission line using distance protection relay and of transformer using multi function numeric transformer protection relay.

The protection relays are connected to RTU/ SCADA over RS485 to display all fault records on SCADA screen

Emergency stop mushroom switch is provided with security

key lock on the vertical profile rack.

Facilitates easy and safe wiring by students due to use of 4mm sturdy Shrouded banana patch cords and shrouded socket arrangements for high voltage circuits.

Each panel has ABS molded plastic sturdy enclosure, and colorful screwless overlays showing circuits diagrams & its connection tag numbers for easy understanding and connection.

Useful for Post Graduate projects and research purpose. Set fo Instructor Guide & Student Workbook.

### Technical Specifications

This trainer can work only in standalone mode with simulated grid sources as well as in conjunction with HMI, RTU SCADA software and consists of following panels:

#### Input 3 phase DOL Starter panel (TMT1) X 1Nos

- 4 pole MCB of 415 v/20A.
- Dol 16A Contactor with 24DCV / 11VACOIL
- Bimetallic thermal O/L relay with range 2.5A - 6A
- RYB inputs indicators
- 9 pin D (M) connector for SCADA interface
- Manual start / stop with local trip contact
- power ON LED indicator

#### FWD-OFF-REV, Switch panel (TMT 4A) X 1 Nos

- FWD/REV, 3 pole 3 wayswitch center OFF, 6A/440V.

#### 3 phase Bidirectional Power cum Energy meter panel (TMT 34) X 3 Nos.

- Bidirectional Multifunction
- 3 phase 3/4 wire, 415VAC, CT Input 5A
- LCD / LED display, Aux, supply 230V, 45-65Hz,5W
- Measure V.I., Hz, Pf, KVA, KW, KWH
- Modbus RTU RS 485 for SCADA

#### VAR Compensation panel (dual panel) (TMT 43) X 1 No.

- Consisting of VAR compensating capacitors of 2, 4, 6, 8, 10 & 15 $\mu$ F each of 3 nos with 3 pole 7 way switch for selection

#### Differential Relay (Transformer protection) panel

#### (TMT 47C) X 1 No.

- Protections: Differential, over current, under/over voltage, under/over frequency, reverse power, earth fault
- 9 pin D connector to interface with SCADA automation
- moduls RTU RS485 for RTU/SCADA interface

#### CT panel (TMT 48) X 2 Nos

- Consist of 5/5 Amp. CT 6 nos
- Primary side of CTs are brought on 3 X 2 X 2 SBS socket
- Secondary side of CTs are star connected in group of 3 & brought out on 4 X 2 SBS-5 sockets

#### Distance protection relay panel (TMT 53) X 1 No.

- Protections: Distance, over current, under/over voltage, earth fault
- Auto reclose function of relay
- 9 pin D connector to interface with SCADA automation
- Modbus RTU RS 485 interface for SCADA

#### 415/110VAC, 50VA PT panel (TMT 54) X 1 No.

- Consisting of potential transformer,
- Input 415VAC, star connected, Output 110VAC, star connected, 50VA

#### 37 pin D (M) to 9 pin (F) converter panel (TMT 62) X 1 No.

- Consist of 37 pin D type male 1no., 9pin D type male 1 no.
- 9 pin D type female connectors 9 nos

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- Power ON LED
- 5 pin to shrouded socket converter panel (TMT 63) X 2 No.**
  - Consist of 5 pin 3 phase, 5 wires industrial female socket to connect 415VAC 3 phase supply
  - shrouded banana sockets 18 nos to extend the 3 phase supply into individual setups
  - It's used as bidirectional 3 phase extension board between two setups

**Table top panels:**

**Distribution transformer panel (TMT 54D) X 1No.**

- 3 phase power transformer with connection group YY11,
- Input 415VAC, Output 415VAC, 3KVA
- Secondary winding with tapping at  $\pm 2.5\%$  and  $\pm 5\%$

**Transmission line panel TL2 (TMT 38A & 42E) X 1 No.**

**Table Top Panel consisting of:**

- Simulated model for transmission line (250kms) using R(10ohm/600W), L(0.15H/5A) & C (2.2uF/630V) 6 No. each component.
- Simulated model for medium/long length transmission line for pi model
- Simulated model for medium/long length transmission line for T model
- Fault resistor 100ohm/600W
- Multi pin heavy duty connector 32 pin & 24 pin to establish control from RTU/SCADA

**RLC load panel (TMT 42A & B/C) X 1 No.**

- 3 nos of 600W resistors with switch selectable 6 nos of taps at 100, 112, 150, 175, 200 & 225 ohm
- 3 nos of inductor 1.5H/1A with switch selectable 6 nos of taps at 0.3, 0.6, 0.75, 0.9, 1.2 & 1.5H
- Capacitors 440VAC rating (3 nos, one per phase) with switch selectable 7 nos of value of 2, 5, 10, 15, 20, 30 & 50 $\mu$ F
- Multi pin heavy duty connector 32 pin & 24 pin to establish control from RTU/SCADA

**Mechanical Dimension (mm) / Wt. (kg):**

- Rack: 1170(L) X 300(W) X 990(H) / Net Wt.: 65, Gross Wt.: 73
- TL1: 600 (L) X 385(W) X 500(H) / Net. Wt: 103
- RLC load panel: 600 (L) X 275(W) X 500(H) / Net Wt.: 60
- Distri. X'mer: 700 (L) X 275(W) X 435(H) / Net. Wt: 53

**Accessories:**

**a) Table for Transmission & Distribution Setup: 1 no. consist of Pi type frame**

- Frame: 45X45 aluminum profile (Heavy duty) Colour: anodized white.
- Table top material/colour: The nova pan or

- Rubber wood with white/Silver gray with smooth finish veneer finish table top (25mm thickness) with removable slot cover (900X500mm)
- Under trolley: Located under individual setup table to house respective load panel, transmission line panel, variac panel, transformer etc as applicable
- Dimension: Table: 1450mm (L) X 750mm(W) X 760mm(H) under trolley: 1200X700X185
- Caster wheels: Four sturdy castor wheels with locking mechanism are provided so that table can be positioned conveniently

**b) Cables:**

- 9 pin D male to 9 pin D female with 9 core cable, length up to 4 meter - 4 nos
- 37 pin D male to 37 pin D female patch cable, length 4 meters - 1 nos
- RS 485 patch cable: 6 pin mini DIN male to 6 pin mini DIN male, length up to 4 meter - 5 nos

**c) Signal tower:** 4 nos. of fixed function lamps and 1 Alarm sound all mounted one above another in classic bayonet system by means of simple half rotation manual operation, mounted on right vertical member of the TLD rack and are driven from 24V DC output of PLC using 37 pin D converter panel. The signal tower is used to indicate following conditions-

- Red lamp paralleled with sounder- When any relay trip, red lamp will flash at 0.75Hz and the alarm is sound until fault accept button is pressed
- Orange lamp: When an emergency stop button is pressed, the 3 ph. supply of Grid and generator is mode OFF and orange lamp will flash at 0.75Hz until fault accept button is pressed
- Green lamp: When Default state is pressed green lamp will ON for 1sec & OFF for 3 sec which indicate all CB's and isolator OFF. When any of the CB or isolator is switched ON then green light will flash at 0.75Hz indicating SCADA in operation
- Blue lamp: When grid is AUTO synchronized with generator the blue will flash at 0.75Hz

**List of Experiments:**

- Study of No load test ferranti effects on transmission line.
- Load test and calculation of efficiency, regulation and power flow in pi model of TL
- Load test and calculation of efficiency, regulation and power flow in short model of TL
- Study of symmetrical and asymmetrical faults on transmission line.
- Study of distance protection using distance relay.
- Study of Auto reclose function of distance relay.
- Study of Distribution transformer protection for differential & over current faults.

Note: Specifications are subject to change.

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